Remote Monitoring of Dolphins and Whales in the High Naval Activity Areas in Hawaiian Waters

Whitlow W. L. Au and Marc O. Lammers
Marine Mammal Research Program
Hawaii Institute of Marine Biology
phone: (808) 247-5026 fax: (808) 247-5831 email: wau@hawaii.edu

Award Number: N000140810903

LONG-TERM GOALS

The axiom that knowledge is power applies directly to the problems experienced by the U.S. Navy in encountering dolphins and whales. These encounters can be avoided if more knowledge and understanding of the behavior, distribution, and movements of these animals. Simply stated, if the Navy had more knowledge of the **what**, **where**, **when** and **why** of marine mammals in a given body of water, encounters between Naval vessels and marine mammals could be reduced or avoided all together. The ocean is large and the chances of avoiding any interaction with any sizable group of marine mammals are probably much greater than the probability of encountering marine mammals. However, the cost of negative encounters is disproportionately high in terms of negative publicity and law suits so it would be prudent to take steps to increase the odds against any encounters. Therefore, basic information on the biology, natural history, and behavior of cetaceans that frequent waters of high Navy activity are needed to understand ways to avoid encounters. A robust database of this information currently does not exist. There is a higher probability of Naval encounters with marine mammals in Hawaiian waters than in most other regions of the world because of the large number of cetacean species that inhabit or frequent these waters. Approximately 16-20 species of cetaceans can be found in Hawaiian waters. This is a large number of species for such a small geographic area. Knowing **what** animals are present in a given body of water is important because different species utilize their habitat in different ways. Therefore, it is important to understand the distribution, abundance and movement of dolphins and whales over the day-night cycles and seasonal periods.

OBJECTIVES

The objective of this study is to map the distribution and abundance of whales and dolphins in selected regions of Hawaiian waters. The waters surrounding the islands of Kauai and Oahu, where most Naval activities occur, will be the focus of this study. The Pacific Missile Range is in the waters of Kauai and the Pearl Harbor Naval Base is the home of the U.S. Pacific Fleet.

APPROACH

Five relatively low-cost autonomous, remote acoustic recorder denoted as the **EAR** (Ecological Acoustic Recorder) have been deployed around the island of Kaui and five more EARs are moored around Oahu, to simultaneously monitor for the presence of dolphins and whales. The EARs are retrieved, reburbished and redeployed after a battery change and swapping of hard drive on a periodic basis. The

<table>
<tr><td colspan="4">Report Documentation Page</td><td colspan="2">Form Approved
OMB No. 0704-0188</td></tr>
<tr><td colspan="6">Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</td></tr>
<tr><td colspan="2">1. REPORT DATE
2010</td><td colspan="2">2. REPORT TYPE</td><td colspan="2">3. DATES COVERED
00-00-2010 to 00-00-2010</td></tr>
<tr><td colspan="4" rowspan="3">4. TITLE AND SUBTITLE
Remote Monitoring of Dolphins and Whales in the High Naval Activity Areas in Hawaiian Waters</td><td colspan="2">5a. CONTRACT NUMBER</td></tr>
<tr><td colspan="2">5b. GRANT NUMBER</td></tr>
<tr><td colspan="2">5c. PROGRAM ELEMENT NUMBER</td></tr>
<tr><td colspan="4" rowspan="3">6. AUTHOR(S)</td><td colspan="2">5d. PROJECT NUMBER</td></tr>
<tr><td colspan="2">5e. TASK NUMBER</td></tr>
<tr><td colspan="2">5f. WORK UNIT NUMBER</td></tr>
<tr><td colspan="4">7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Hawaii Institute of Marine Biology,Marine Mammal Research Program,PO Box 1106,Kailua,HI,96734</td><td colspan="2">8. PERFORMING ORGANIZATION REPORT NUMBER</td></tr>
<tr><td colspan="4" rowspan="2">9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</td><td colspan="2">10. SPONSOR/MONITOR’S ACRONYM(S)</td></tr>
<tr><td colspan="2">11. SPONSOR/MONITOR’S REPORT NUMBER(S)</td></tr>
<tr><td colspan="6">12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited</td></tr>
<tr><td colspan="6">13. SUPPLEMENTARY NOTES</td></tr>
<tr><td colspan="6">14. ABSTRACT</td></tr>
<tr><td colspan="6">15. SUBJECT TERMS</td></tr>
<tr><td colspan="3">16. SECURITY CLASSIFICATION OF:</td><td rowspan="2">17. LIMITATION OF ABSTRACT
Same as Report (SAR)</td><td rowspan="2">18. NUMBER OF PAGES
6</td><td rowspan="2">19a. NAME OF RESPONSIBLE PERSON</td></tr>
<tr><td>a. REPORT
unclassified</td><td>b. ABSTRACT
unclassified</td><td>c. THIS PAGE
unclassified</td></tr>
</table>

data disk are taken back to the laboratory for analysis. Various species of cetaceans are of interest, but for the first two years, the effort has been concentrated on deep diving beaked whales around Kauai and at one location off Oahu.

The EAR, jointly developed by the Hawaii Institute of Marine Biology (HIMB) and the Coral Reef Ecological Division of NOAA's Pacific Islands Fisheries Science Center has a maximum sampling rate of 80 kHz with a hydrophone that is functional up to 40 kHz and records data to a 160 Gbyte laptop recorder. It can be deployed to depths down to 1000 m. The EAR is controlled with a Persistor Instrument CF2 microcontroller. Its deployment life is determined by the programmable recording duty cycle and the number of battery packs included, but typical deployment durations range between 4-12 months. At its maximum sampling rate, it is capable of recording the calls of all cetacean species found in Hawaiian waters, including beaked whales.   Maps of deployment sites around the islands of Kauai and Oahu are shown in Figure 1.

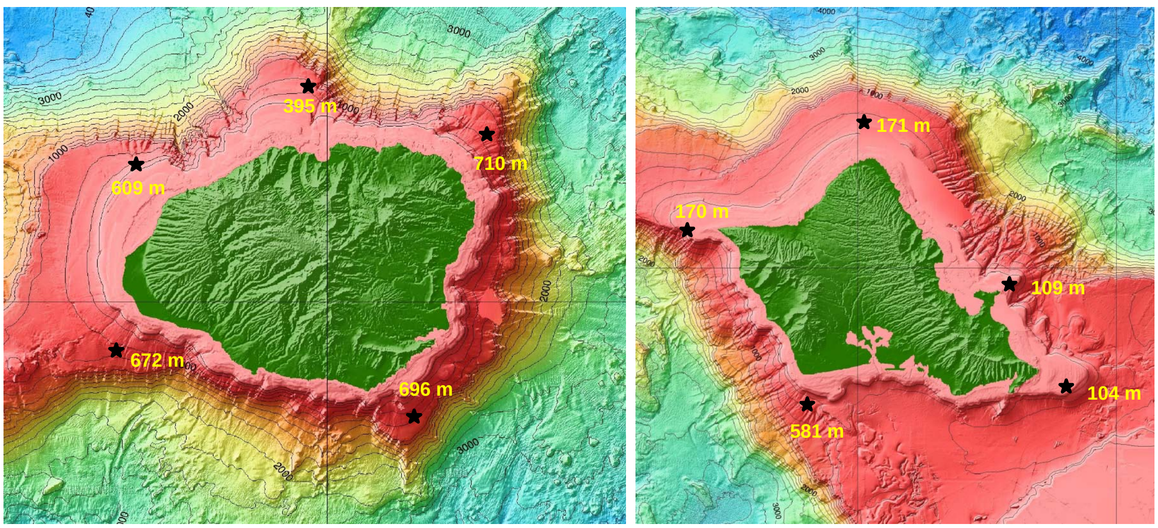

Figure 1. The potential locations around the islands of Kauai and Oahu where EARs (stars) operating simultaneously will be deployed during the first year.

WORK COMPLETED

Five EARs were deployed around the island of Kauai and five around the island of Oahu in February, 2009 at the locations shown in Figure 2. The depth of the EARs at each site is also shown in the figure. Four of the EARs around Kauai are at depths between 600 and 700 m while on the north end of Kauai it is at approximately 400 m. The EARs around Oahu are at shallow depths with four between 114 m and 170 m and one unit at 576 m. Each unit was programmed to turn on and collect data for 30 sec every 5 minutes. Three deployments and retrieval followed by re-deployment have taken place. During each re-deployment the laptop disk holding the acoustic data are swapped with fresh disk along with a swapped out of the battery packs. Echolocation signals have been detected at all five sites at different times and the data is currently being organized so that a coherent description of echolocation activities can be presented in terms of the monthly and diurnal occurrence.

Two important events have taken place during this reporting period. First the sample rate for the EAR was increased from 64 kHz to 80 kHz for the 3rd redeployment. The sample rate increase was done to better detect beaked whale signals. Second, the project received an M3R nodes in late August,

2010, courteousy of David Moretti, of the Naval Undersea Warfare Center Division in Newport, R.I. and Dr. Frank Stone, of N45. The node is currently being used to process the data from Kauai and for the EAR off Barbers Point, Oahu, which is at a depth of 581 m. The M3R system is designed to detect both Blainville and Cuvier beaked whales. Eventually all the EAR data will be analyzed with the M3R node.

RESULTS

Histograms showing the detection of deep diving echolocators by the EARs in the water of Kauai are shown in Figure 2 for the five locations. The EAR in the waters of N Kauai is temporarily out of commission having failed to release from its bottom anchor during the redeployment in January, 2010. Attempts will be made on the next deployment to retrieve that EAR. The EAR at the SW site failed to operate properly on the 2nd deployment, probably because of a faulty disk. The unit did operate properly during the 3rd deployment. The data in Figure 4 do not suggest any pattern or favorite sites for deep diving echolocators. There seems to be a continual shifting in the pattern of clicks used by deep diving echolocators. For example, when the most clicks are detected at one site during a particular month the highest click count will be most likely be elsewhere the next month. In Figure 2, the SE site detected the most clicks in January of 2010, but the count dropped in February, and the EAR at NW site had the highest count.

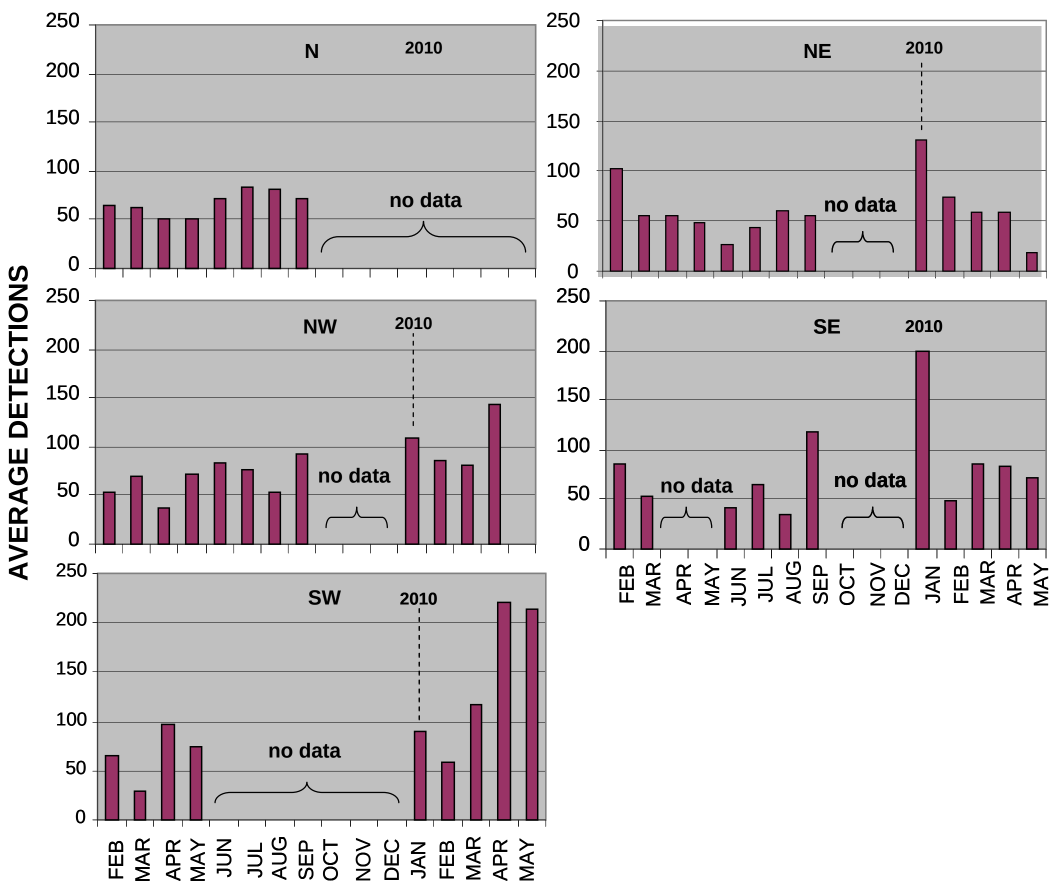

Figure 2. Histogram of average detection per day of deep diving echolocating odontocetes at the five EAR locations off Kauai EAR.

The number of clicks detected by four of the EARs during the month of March, 2010 are shown in Figure 3. The data for this single month suggest again, as did the monthly averaged data, that there is not any "hot" spots around the island of Kauai. However, the EAR at the SW site did detect the highest number of clicks. For the results shown in Figure 3 made no attempt was made to separate beaked whale clicks from any number of deep diving echolocators. The data set

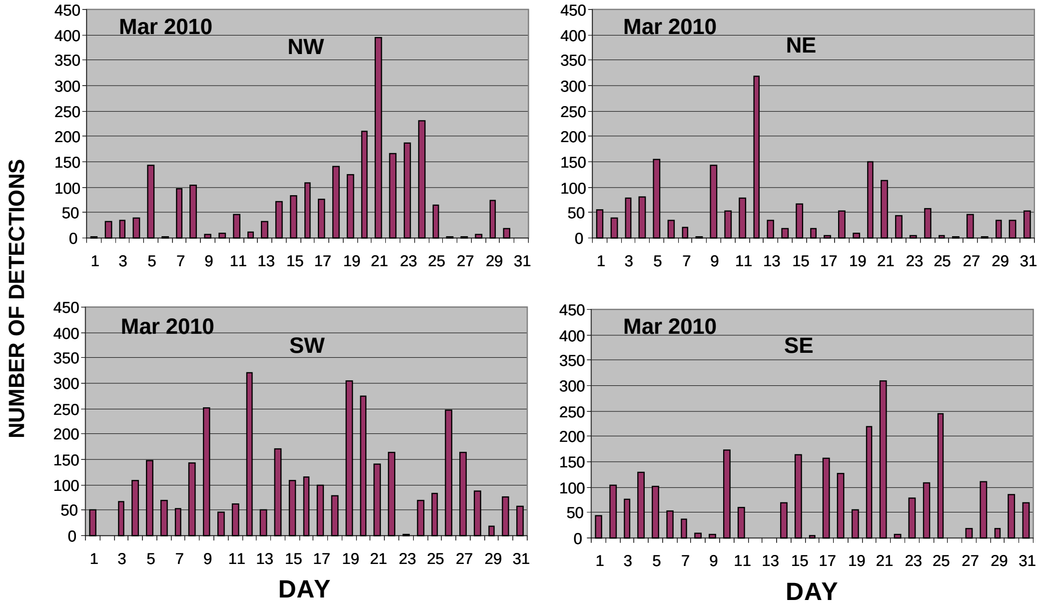

Figure 3. Detection of echolocation clicks from deep diving odontocetes IN March, 2010.

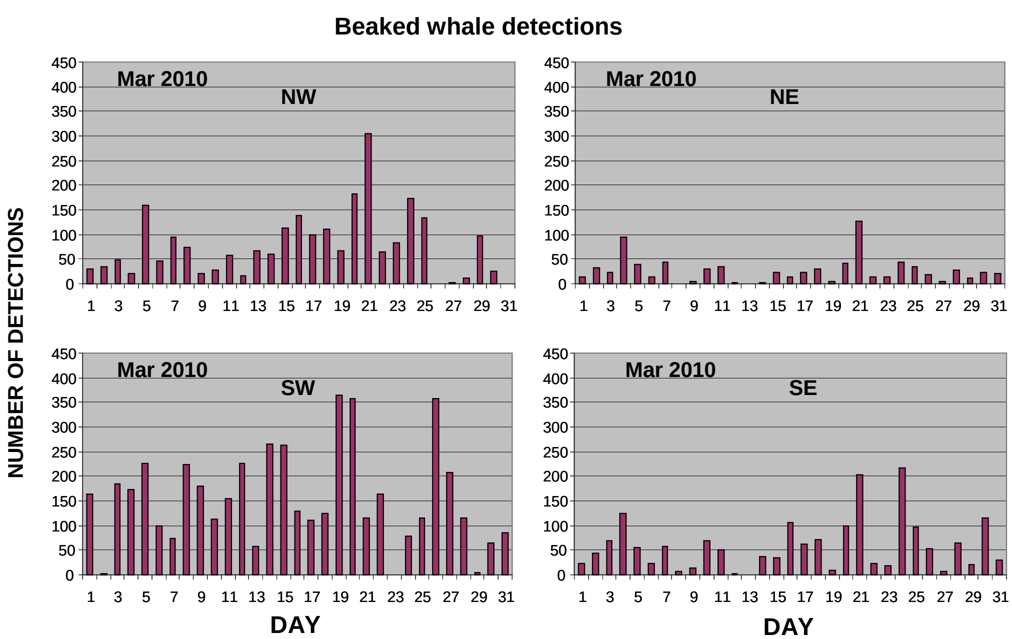

Figure 4. Detection of beaked whale signals during the month of March, 2010. The histogram shown in this figure can be compared with the general click detection results of Figure 3.

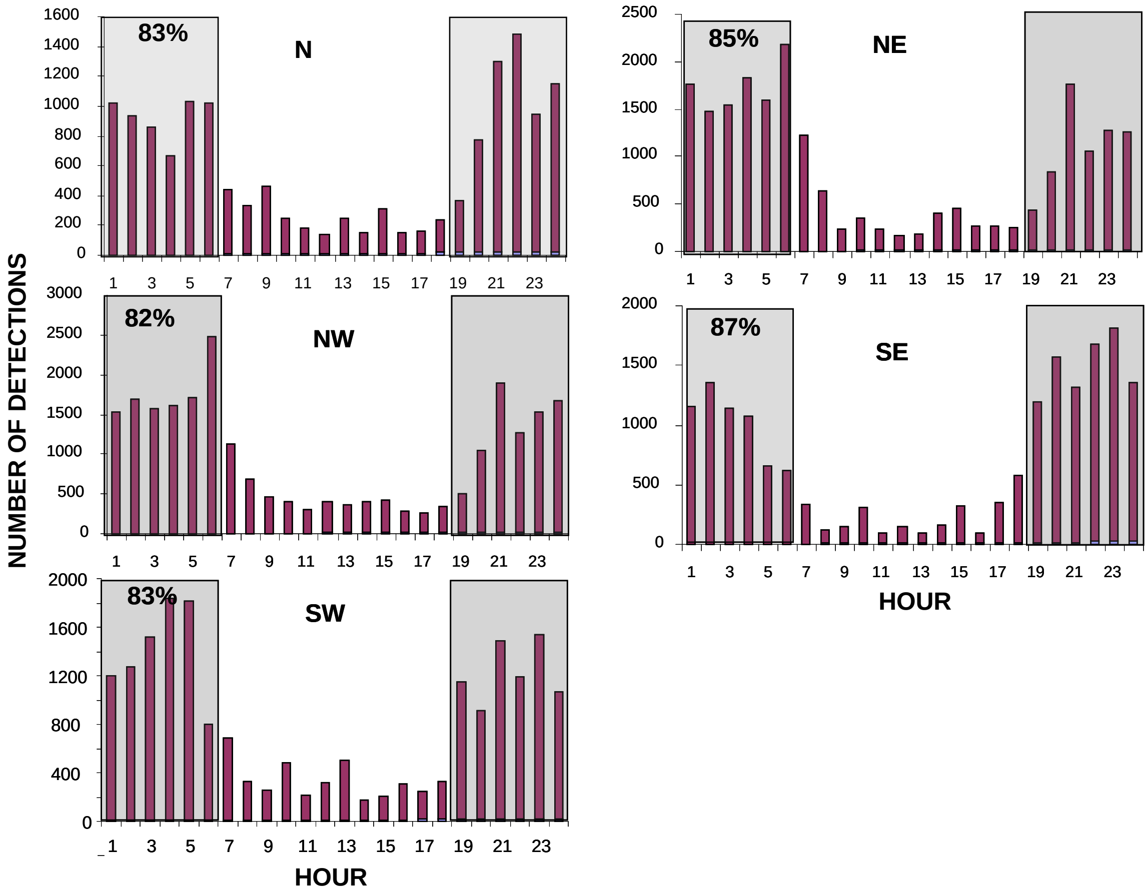

Figure 5. The number of clicks detected as a function of hour in a day. The histograms should be examined on a relative basis without comparing the number of detections between sites because the data represent different number of days between sites.

from the latest retrieval after the sample rate was increased to 80 kHz was analyzed with the M3R node. The results of the support vector machine (SVM) detector (which also uses click interval information) are shown in Figure 4 for the month of March, 2010. A casual comparison between Figures 3 and 4 suggest that most of the clicks detected by our own general click detector could be ascribed to beaked whale. Eventually, all the data will be analyzed with the M3R node.

IMPACT/APPLICATIONS

Potential future impact for Science and/or Systems Applications is gaining knowledge of how dolphins and whales utilize the waters surrounding Kauai and Oahu, two areas of high Naval activities and from that knowledge, operations can be planned that would maximize the probability of avoiding marine mammals. Successful results and methods used in this project could also be applied to other areas of high Naval activities.

RELATED PROJECTS

Participated in Sirena-10 cruise by the NATO Undersea Research Centre off Portugal by providing an EAR and technical assistance as well as a graduate student assistant during the cruise.